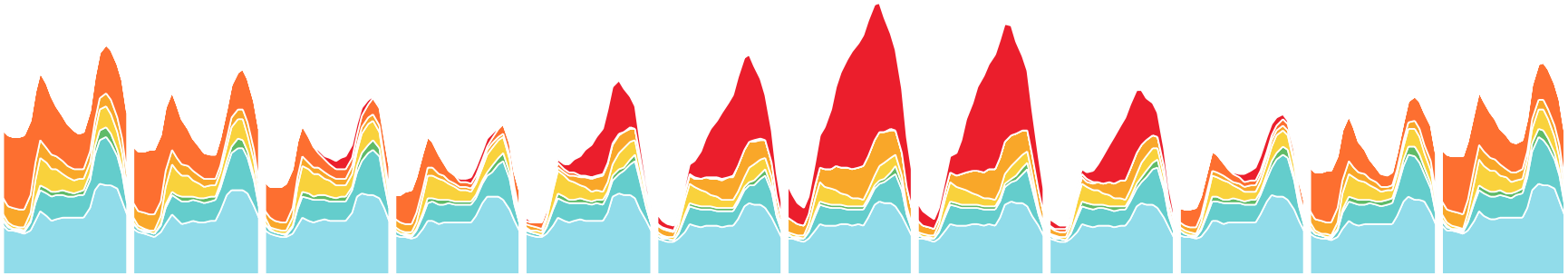
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

New project in FY19

End-Use Load Profiles for the U.S. Building Stock



Performing Organizations: National Renewable Energy Laboratory (NREL)
Lawrence Berkeley National Laboratory
Argonne National Laboratory

Principal Investigator: Eric Wilson, Senior Research Engineer, NREL
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Project Summary

New project in FY19

Timeline:

Start date: 10/1/2018

Planned end date: 9/30/2021

Key Milestones

1. Technical Advisory Group established; 12/31/18
2. Year 1 Report; Go/No-go Decision 8/1/19

Budget:

Total Project $ to Date:

- DOE: $3,000,000
- Cost Share: $0

Total Project $:

- DOE: $9,000,000
- Cost Share: $1,000,000*

*anticipated

Key Partners:

Northeast Energy Efficiency Partnerships
Electric Power Research Institute
Northwest Energy Efficiency Alliance
New York State Energy Research and Development Authority
Massachusetts Clean Energy Center

Project Outcome:

The project is focused on producing a nationally comprehensive, validated dataset of end-use load profiles for the U.S. building stock.

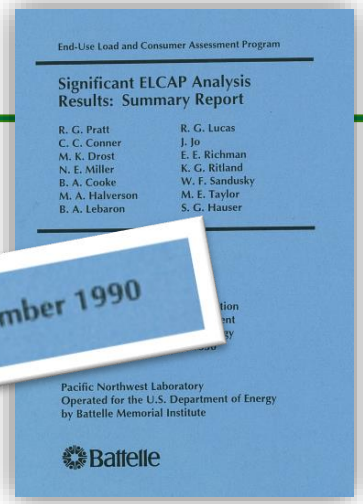
This dataset is needed to enhance understanding of the time-sensitive value of energy efficiency and energy flexibility, so that utilities, states, and cities continue to invest in "**improving the energy efficiency of our homes and buildings**" (*EERE Goal 3; BTO Multi-Year Program Plan FY16–FY20, p11*).

Beyond the dataset, the project will result in validated modeling capabilities for evaluating how building technologies can "**enable the integration of clean electricity into a reliable, resilient, and efficient grid**" (*EERE Goal 5; BTO Multi-Year Program Plan FY16–FY20, p11*).

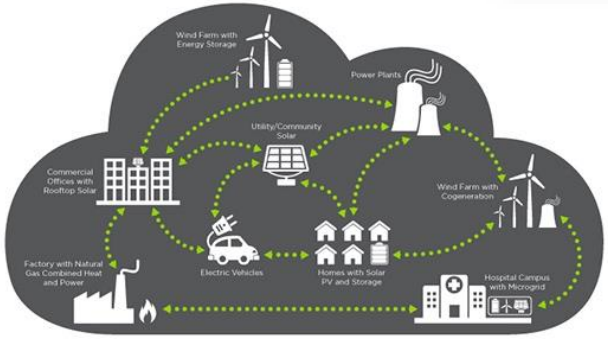
Challenge

Existing end-use load profiles

- are often outdated and limited to certain regions and building types because of the **high cost** of traditional end-use sub-metering



- are insufficient for accurate evaluation of numerous **emerging use cases** of grid-interactive and efficient buildings



Source: Navigant

Opportunity

- New ResStock™ and ComStock™ models statistically represent energy use of U.S. buildings
- Models produce hourly end-use load profiles, <u>but calibration efforts to date have focused on annual energy use</u>

ResStock

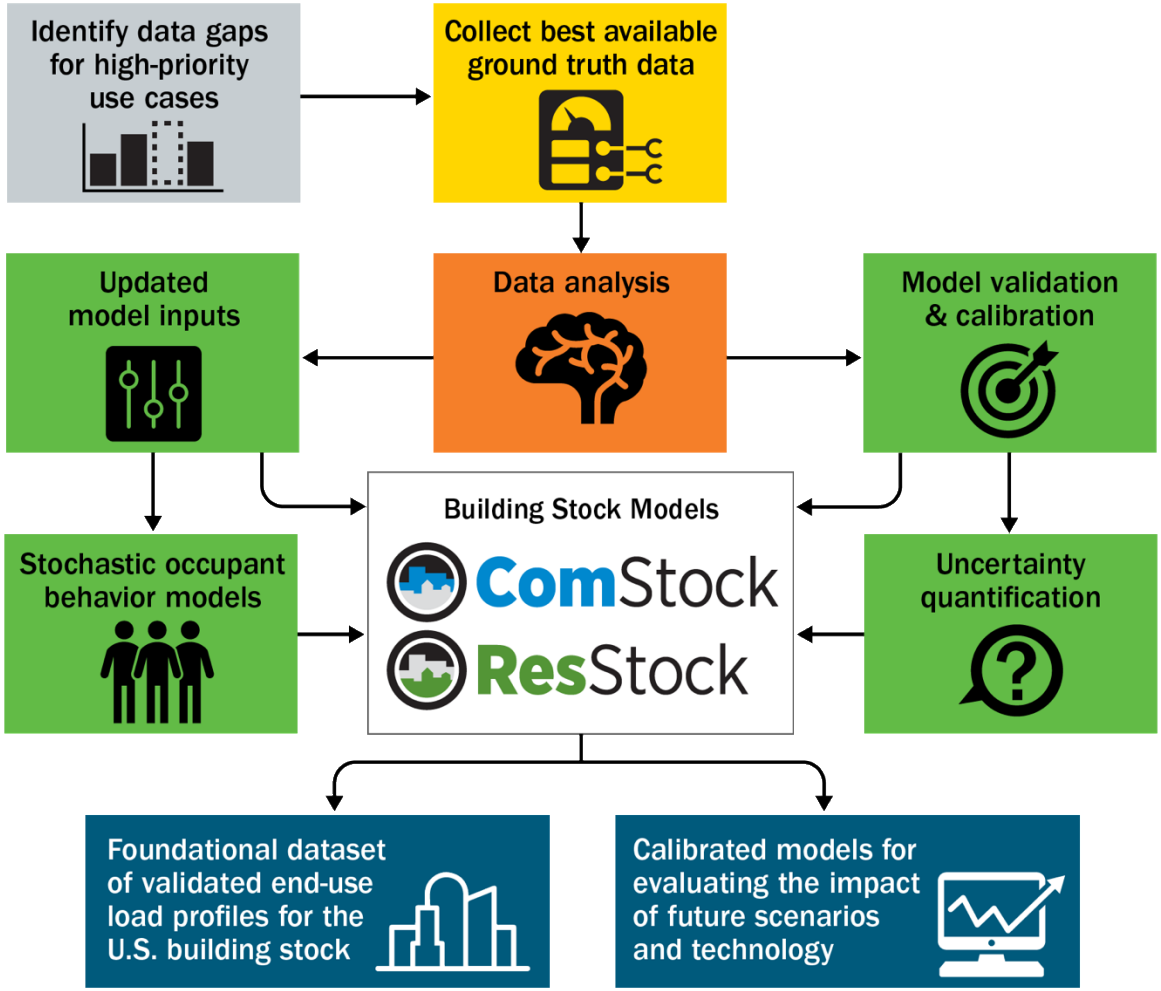
ComStock

Approach

Hybrid approach combines best-available ground-truth data—

- submetering studies,
- statistical disaggregation of whole-building interval meter data, and
- other emerging data sources

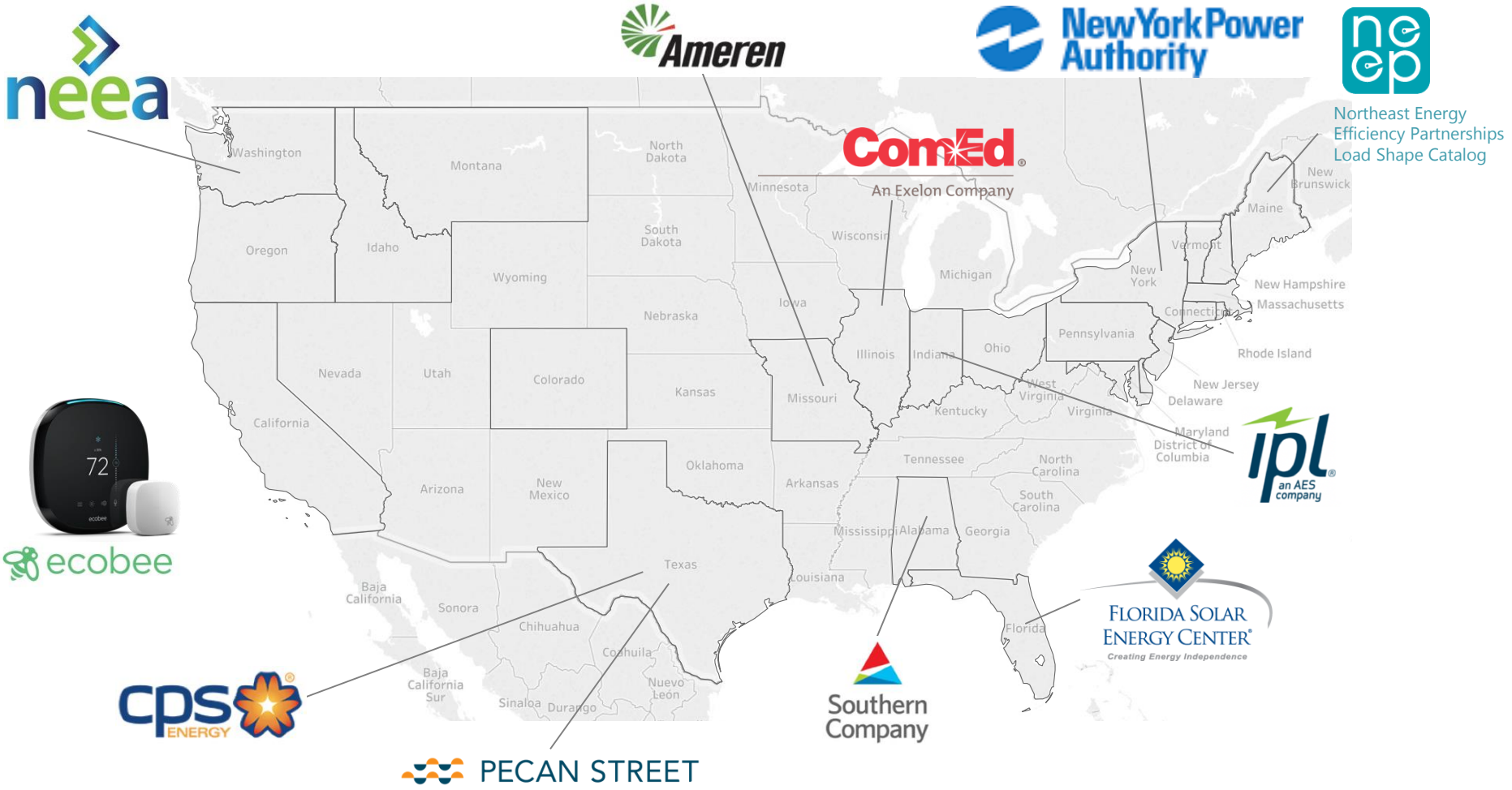
—with the reach, cost-effectiveness, and granularity of physics-based and data-driven building stock modeling capabilities



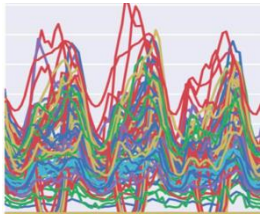
The novel approach delivers a nationally-comprehensive dataset **at a fraction of the historical cost.**

Approach – Examples of Data Sources

Acquired or actively pursuing 20 (and growing) data sources from around the U.S. – *Selected examples:*



Approach – Example Data Source Usage



Load research data
- 192 customer class profiles from 30 utility companies
- 60-min interval data
- E.g., residential w/o electric heat, large general service

Value derived through analysis

- Sector total ground truth
- Non-weather dependent load shape/magnitude
- Cooling/heating season length/magnitude

ComEd
An Exelon Company

ComEd Anonymous Data Service
- All ~4 million meters in northern Illinois
- 30-min interval data
- Meters tagged with ZIP/ZIP+4 code and customer class

All listed above, plus
- Diversity in customer base load and cooling/heating patterns
- Statistical conditional demand disaggregation (if paired with saturation surveys)
- Demographic correlations

neea

Residential Building Stock Assessment: Metering Study (2011)
- 100 homes in northwest U.S.
- 15-min sub-metered circuits
- Home audit data available from larger RBSA study

All listed above, plus
- End-use ground truth data for one region (some end-uses transferrable to other regions)
- Correlations with audit data

Proposal Team

Organization

Key Team Members

NREL


Eric Wilson (PI)


Andrew Parker (Co-PI)


Dr. Rajendra Adhikari


Dr. Jianli Chen


Dr. Lieko Earle


Rawad El Kontar


Dr. Anthony Fontanini


Dr. Sammy Houssainy


Dr. Janghyun Kim


Elaina Present

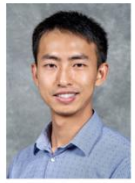

Dr. Janet Reyna

BERKELEY LAB
Lawrence Berkeley National Laboratory


Natalie Mims Frick (Co-PI)


Lisa Schwartz


Dr. Tianzhen Hong


Han Li


Tom Eckman

Argonne NATIONAL LABORATORY


Dr. Ralph Muehleisen


Dr. Qi Li

EPRI ELECTRIC POWER RESEARCH INSTITUTE


Chris Holmes


Krish Gomatom

neep Northeast Energy Efficiency Partnerships


Elizabeth Titus


Claire Miziolek

Proposal Team – Expertise

Organization	Domain expertise
NREL	Building energy modeling (BEM) Building stock modeling Residential occupant behavior
Lawrence Berkeley National Laboratory	Time-sensitive valuation of EE Utility integrated resource planning Commercial occupant behavior
Argonne NATIONAL LABORATORY	Uncertainty quantification
EPRI ELECTRIC POWER RESEARCH INSTITUTE	Load profile conditional demand analysis Electric utility engagement
Northeast Energy Efficiency Partnerships	Northeast regional stakeholder engagement Northeast regional data sources

EnergyPlus OpenStudio

ResStock

ComStock

Impact

A BTO survey found that end-use load profiles are the **most essential data resource** currently missing for time-sensitive valuation of energy efficiency.

End-use load profiles

- are needed by the utility industry to **accurately account for EE and DR** in forecasting, resource planning, distribution system planning, and other applications.

Project results

- Will be used by BTO GEB work moving forward
- Will prioritize DOE R&D investments (e.g., via Scout)

Project results will likely be used by electric utilities across the U.S.

Significant utility industry interest demonstrated by 65 advisory group members contributing their time to the project

Foundation for understanding **demand flexibility**—and its relationship to EE—across the building stock

Progress – Stakeholder Engagement

New project in FY19;
Progress shown is since October 2019 (6 months)

- Created technical advisory group with 65 members representing utilities, regulators, experts and consultants, energy efficiency regional organizations and vendors.
  - Held first technical advisory group meeting in November 2018.
  - Convened second (in-person) technical advisory group meeting in March 2019—focused on identifying market needs, use cases and data gaps.

In-kind participation by 65 advisory group members

Progress – Use Cases, Data Gaps

New project in FY19;
Progress shown is since October 2019 (6 months)

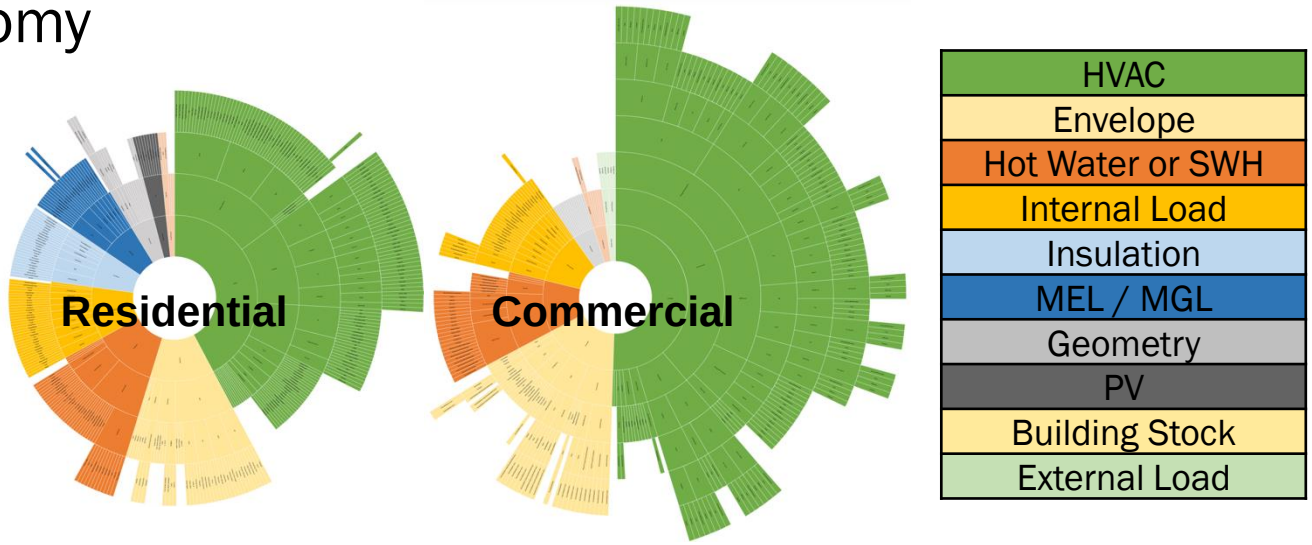
Use Cases

- Identified approximately 75 use cases for end-use load profiles

Data Gaps

- Categorized approximately 500 high-level inputs for ResStock/ComStock,
  - documented the data sources currently being used for each,
  - identified potential data sources for future improvements, and
  - identified the highest priority input data gaps

Parameter taxonomy for gaps analysis



Progress – Occupancy Modeling

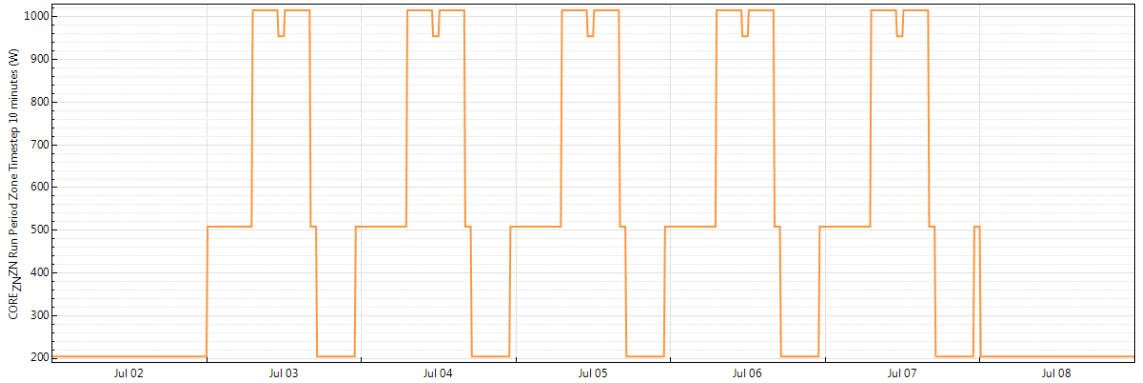
New project in FY19;
Progress shown is since October 2019 (6 months)

Occupancy Modeling

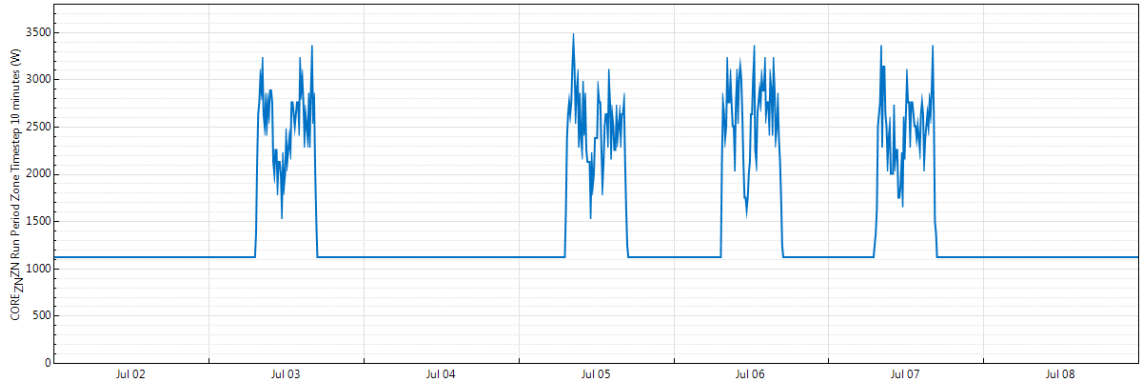
- Completed initial literature review on residential stochastic occupant behavior models
- Progress developing commercial building stochastic occupant behavior models for several commercial building types

Office misc. plug loads

Existing

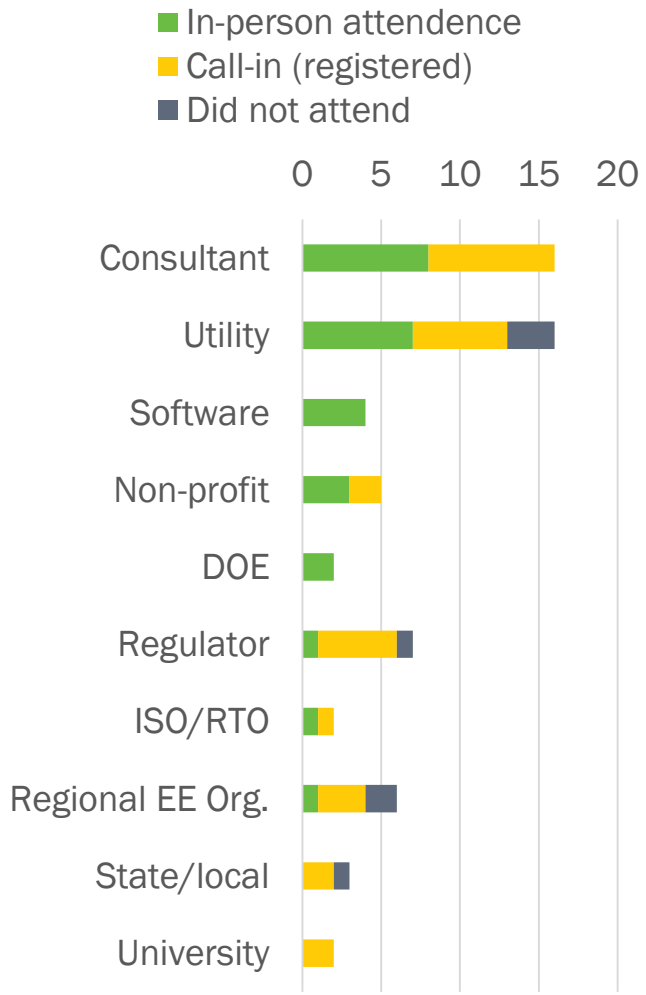


With LBNL's stochastic occupancy model

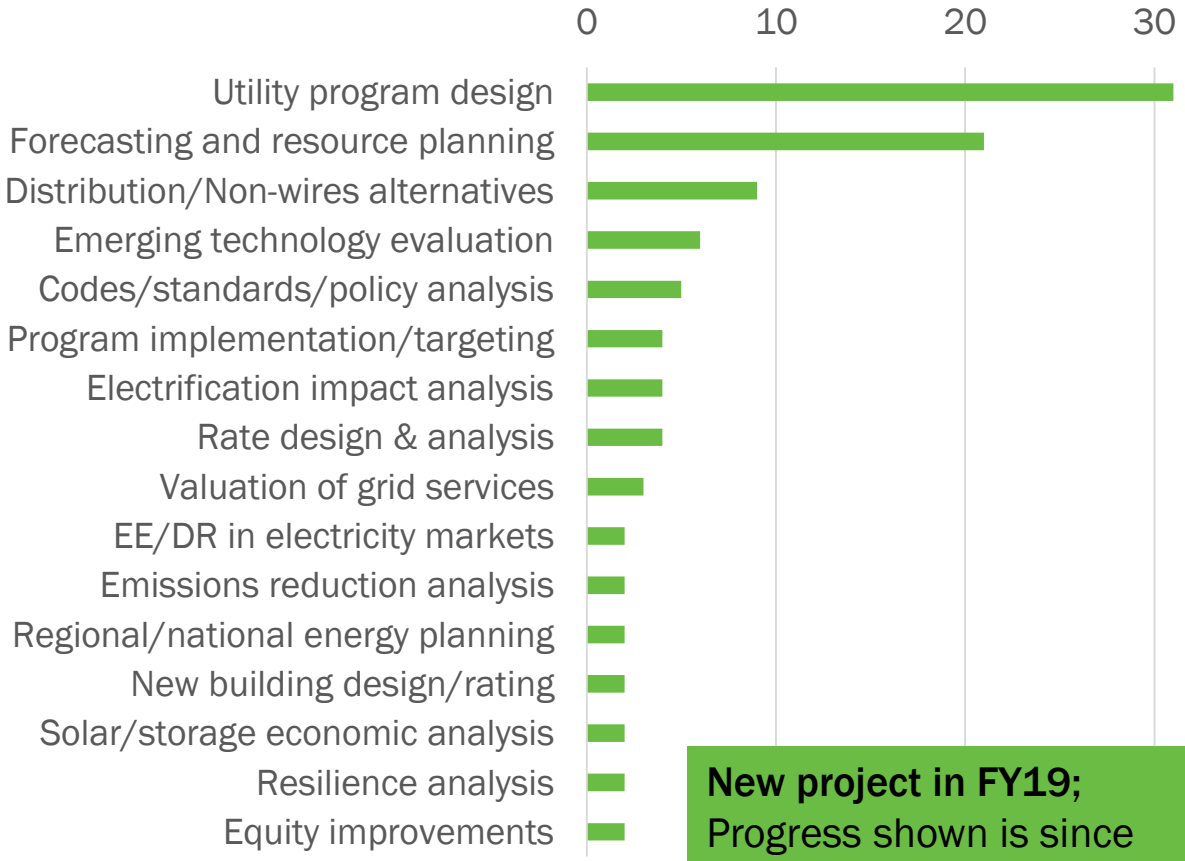


Progress – Stakeholder Use Case Prioritization

Attendees of members at March 5–6 Meeting



List 3 use cases that are high priority for you



New project in FY19; Progress shown is since October 2019 (6 months)

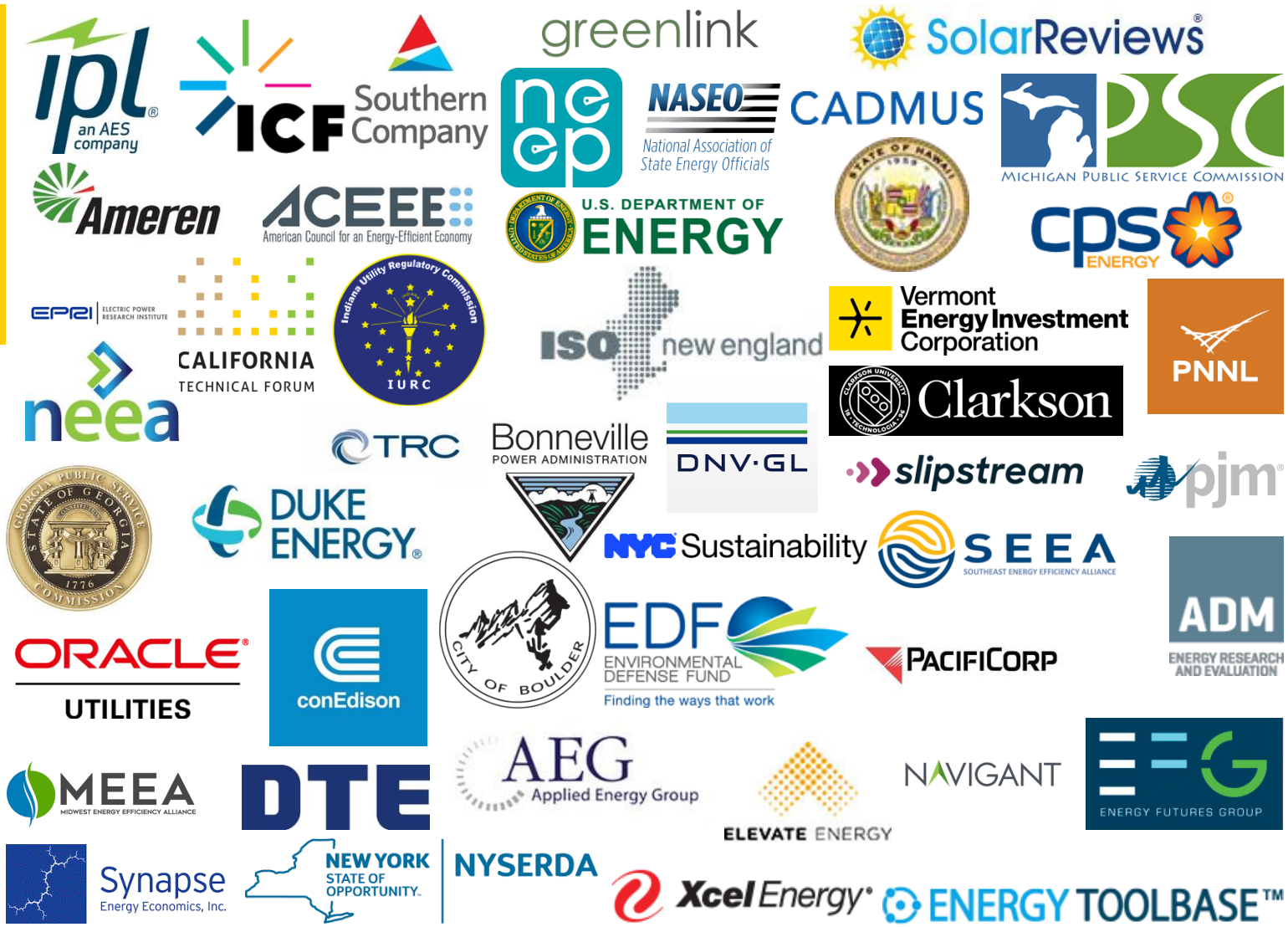
Progress – Top Use Case Data Requirements (DRAFT)

Indicates requirement typically outside status quo

Use Case	Rank	Time resolution	Geographic resolution	End-uses	Stochastic Occupancy	Electrical Characteristics
Utility program design	1	Hourly or peak day	Service territory	Yes	No	Real power
Forecasting and resource planning	2	Hourly or peak day	Service territory	Yes	No	Real power
Distribution/Non-wires alternatives	3	15-min or smaller	Distribution feeder	Yes	Yes	Real, reactive power, voltage
Emerging technology evaluation	4	Depends on rates	Service territory or larger	Yes	Yes	Depends on application
Codes/standards/policy analysis	5	15-min to hourly	State, climate zone	Yes	Yes	Real power
Program implementation/targeting	6	Hourly	Service territory or smaller	Yes	No	Real power
Electrification impact analysis	6	Hourly	Service territory or smaller	Yes	Yes	Real power
Rate design & analysis	6	15-min	Service territory or smaller	No	Yes	Real power
Valuation of grid services	9	Hourly or smaller	Feeders to markets	Yes	Yes	Depends on application
EE/DR in electricity markets	10	15-min to hourly	Service territory or larger	Yes	Yes	Real power
Emissions reduction analysis	10	Hourly	Service territory or larger	Yes	No	Real power
Regional/national energy planning	10	Hourly	Regional or national	Yes	No	Real power
New building design/rating	10	15-min to hourly	Weather station	Yes	Yes	Real power
Solar/storage economic analysis	10	1-min	Weather station	No	Yes	Real power
Resilience analysis	10	1-min to hourly	Distribution feeder or smaller	Yes	Yes	Depends on application
Equity improvements	10	Hourly	Service territory or smaller	Yes	Yes	Real power

Stakeholder Engagement

In-kind participation by 65 advisory group members



Stakeholder Engagement

Technical Advisory Group in-person meeting
March 5–6, 2019

40 non-lab attendees
(including 13 on phone)

"This is a good start"

"This was as good as it gets for engaging people across different locations and disciplines."

"It was very useful to engage in breakout sessions to develop a broader understanding on how people will use these."

"This format worked well."

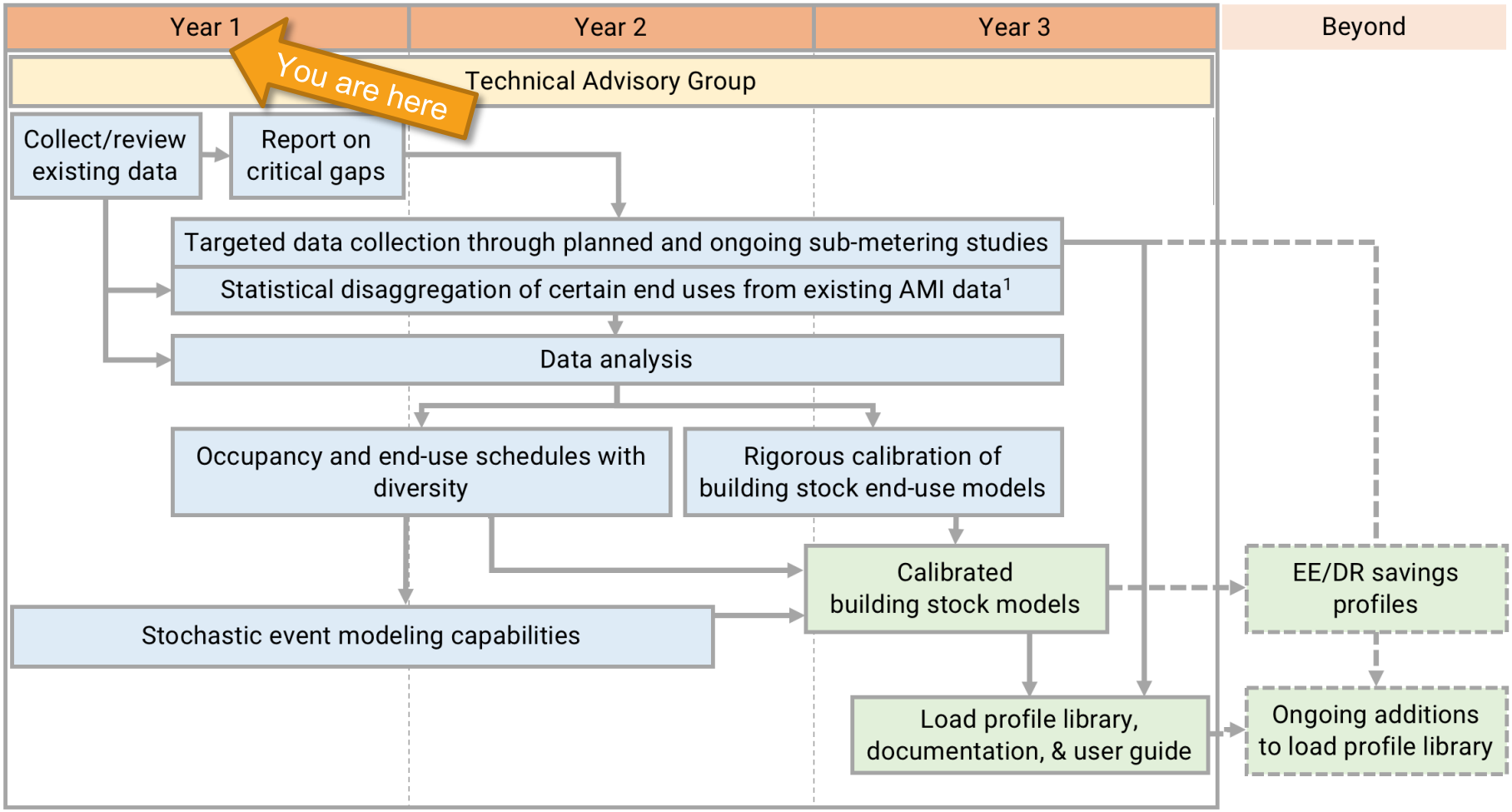
"Phone attendance was nearly seamless and worked really well. Nice work. Good collaboration in breakouts."

"Break out groups were great. Good discussion and facilitation. The lead in presentations were good too."

"…the conversations were ultimately very thought provoking."

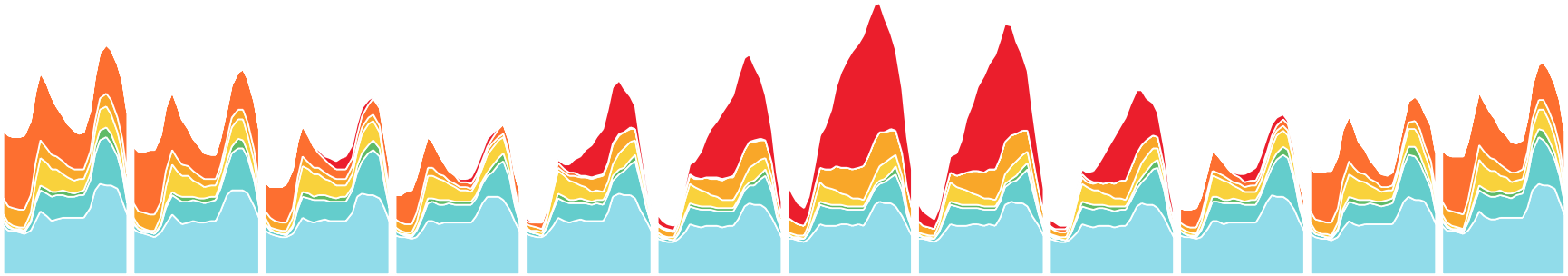
Remaining Project Work

Immediate next steps:
- Report on use cases and critical data gaps
- Continue identifying and pursuing data sources
- Continue developing stochastic occupancy modeling



[1] For example, conditional demand analysis, or inverse (changepoint/degree day) models (KEMA 2009)

Thank You



Performing Organizations: National Renewable Energy Laboratory (NREL)
Lawrence Berkeley National Laboratory
Argonne National Laboratory

Principal Investigator: Eric Wilson, Senior Research Engineer, NREL
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REFERENCE SLIDES

Project Budget

Project Budget: $3,000,000 per year for three years, across three national labs
Variances: None
Cost to Date: *Costing through March 16

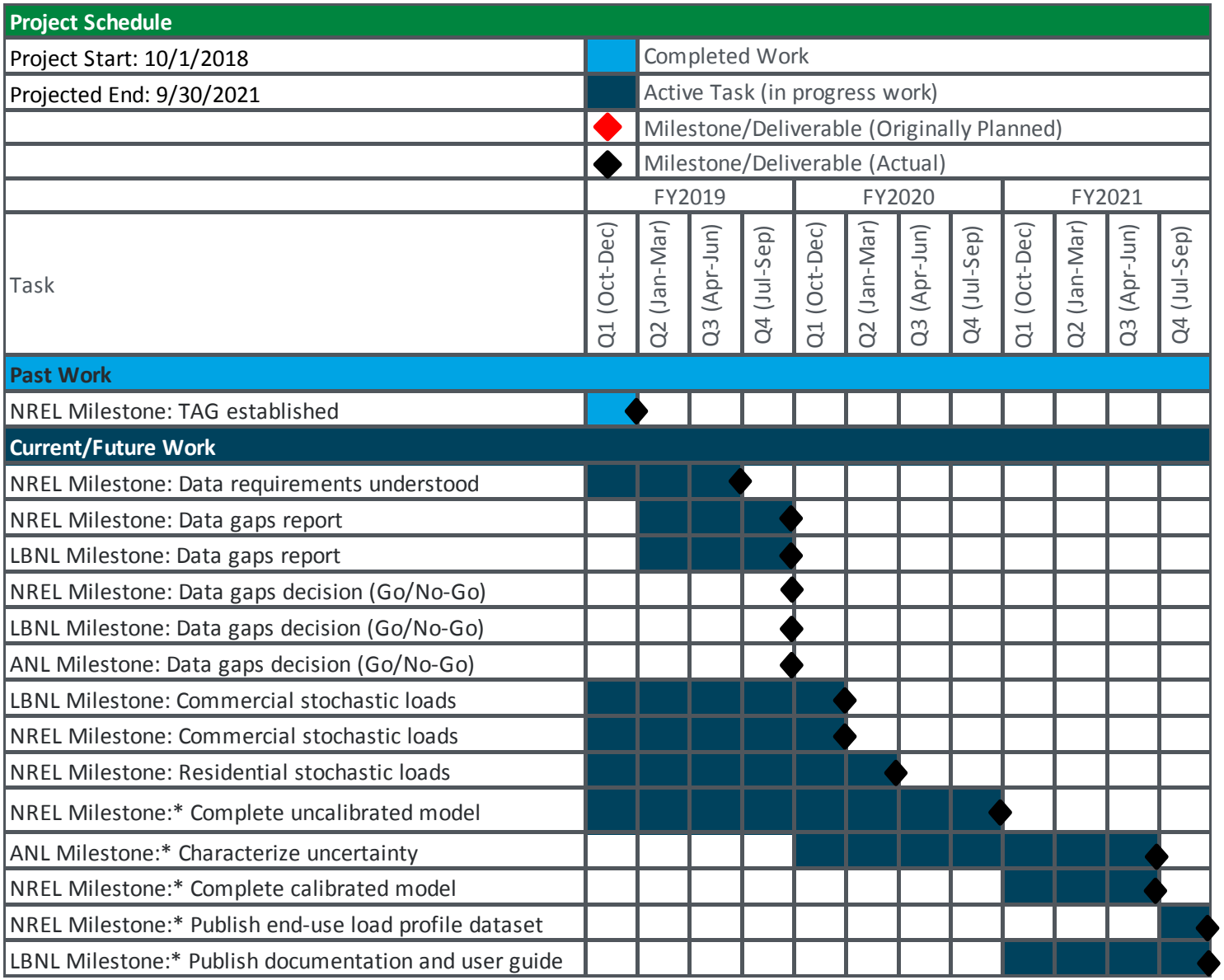
Labs: $290,400* (NREL), $131,500* (LBNL), $7,653 (ANL)
Partners: $0 (NEEP), $0 (EPRI)

Additional Funding:

EPRI's utility partners: $150,000
NYSERDA: $250,000 (funding NEEP activities)
MassCEC: $500,000 (funding NEEP activities)
ComEd: $30,000
Various in-kind contributions for participation in advisory group

Budget History					
10/1/2018 – FY 2019 (current)		FY 2020 (planned)		FY 2021 – 9/30/2021 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$3,000,000	$435,000	$3,000,000	$280,000	$3,000,000	$285,000

Project Plan and Schedule



*Anticipated future year milestone